

## REMARKS

### I. Election of Claims

This Amendment is submitted in response to the Office Action dated April 24, 2009. Claims 1-40 are currently pending in the application. Claims 1, 20, and 37 are the only independent claims. Claims 1, 5, 6, 9, 12, 16, 17, 20, 28, and 37 have been amended by way of this response. Claims 39 and 40 have been added to further define embodiments of the invention. The amendments to the claims have been made in an effort to lend greater clarity to the claimed subject matter and to expedite prosecution. These amendments should not be taken to indicate the Applicants' agreement with, or acquiescence to the rejections of record.

### II. Response to the Rejection of Claims 5 and 6 under 35 U.S.C. 112, 2<sup>nd</sup> Paragraph

The Examiner rejected claims 5 and 6 under 35 U.S.C. §112, second paragraph, as failing to point out and distinctly claiming the inventive subject matter. These rejections are respectfully traversed.

In particular, the Examiner found the terms "first scribing," "second scribing," "third scribing," and "fourth scribing" to be unclear. The terms have been amended to clearly recite that portions of the photoelectrode apparatus have first, second, third, and fourth scribe lines. The scribe lines are clearly shown in the drawings and recited in the specification as first, second, third and fourth scribe lines, 21, 22, 23 and 24. Thus, the scribe lines of claims 5 and 6 are clearly identified as product elements, and not method steps or product by process claim elements. Therefore, Applicants respectfully request withdrawal of this rejection.

### III. Response to the Rejection under 35 U.S.C. §102(b) of Claims 1-5, 20, and 21 as being anticipated by the Owada et al. reference (JP 62-092380).

The Examiner rejected claims 1-5, 20, and 21 under 35 U.S.C. §102(b) as being anticipated by the Owada et al. reference. This rejection is respectfully traversed.

Independent claim 1 recites a photoelectrode that comprises a transparent substrate, a front contact layer, a single or multi-junction semiconductor layer, and a back contact layer. The front contact layer comprises a transparent conducting layer that is deposited on the substrate as a front electrode. The back contact is electrically conductive and forms an electrode that is of an opposite anode or cathode configuration to the front contact. An

insulating layer covers portions of the back contact layer. A conducting layer is electrically connected to the transparent conducting layer. Claim 1 has been amended to positively recite an oxygen evolution reaction layer and a hydrogen evolution reaction layer.

The Owada et al. reference discloses a solar cell having an integrated battery charging function. There is no teaching or suggestion in the Owada et al. reference of an oxygen evolution reaction layer or a hydrogen evolution reaction layer. In fact, Owada is silent with regards to production of oxygen or hydrogen generally. Rather, the Owada et al. reference teaches a solar cell having a capacitor electrically connected thereto in order to provide an electrical output to a secondary battery when no light is present. Thus, the Owada et al. reference fails to teach or suggest either of these limitations and, therefore, cannot anticipate the invention of claim 1.

Claims 2-19 depend from claim 1. For at least the reason stated above in support of claim 1 as being patentable over the Owada et al. reference, likewise claims 2-19 are also patentable. Thus, Applicants respectfully request withdrawal of this rejection.

Claims 20 has been amended to recite a method of making a photoelectrode that includes all of the particulars of the photoelectrode of claim 1. Therefore, claim 20 is likewise patentable for the same reasons stated above in support of claim 1. Since claim 21 depends from claim 20, for at least this reason, claim 21 is also patentable. Thus, Applicants respectfully request withdrawal of this rejection.

#### IV. Response to the Rejection under 35 U.S.C. §102(b) of Claims 37 and 38 as being anticipated over the Nakata et al. reference (US 6,198,037).

The Examiner rejected claims 37 and 38 as being anticipated by the Nakata et al. reference. These rejections are respectfully traversed.

Independent claim 37 recites a photoelectrochemical (PEC) cell that comprises a plurality of strip cells that are formed from a plurality of scribe lines. The plurality of strip cells is electrically connected to form a segmented photoelectrode, where the segments of the photoelectrode are each configured as one of an anode and a cathode. The anode and cathode are in contact with an electrolyte. The PEC cell is divided into compartments for oxygen and hydrogen generation. Ion conduction layers are placed between the compartments and an enclosure confines the electrolyte for electrolysis.

The Nakata et al. reference fails to teach or suggest a photoelectrode having a plurality

of strip cells that are formed from a plurality of scribe lines. The Nakata et al. reference further fails to teach or suggest that the plurality of strip cells are electrically connected to form a segmented photoelectrode having each segment configured as an anode or a cathode. Rather, the Nakata et al. reference teaches a plurality of separate, spear-shaped solar battery modules. The spear-shaped solar modules have spherical solar battery elements contained within a holding member. The solar modules are mounted in the photoelectrolytic device by being pierced through the electrolyte partition member. As shown in each assembly figure of the Nakata reference, the *entire* spear-shaped photovoltaic cell is immersed in the electrolyte. Such an arrangement of the cells and electrolyte diminishes the amount of radiation that reaches the cells. Thus, the spear-shaped solar modules are clearly different from the strip cells of claim 37.

Additionally, the Examiner's rejection of independent claim 37 relies on the statement that "plain water can inherently be acidic or alkaline." This statement has no basis in fact. Pure water, by definition, is neutral since hydrogen ions ( $H^+$ ) and hydroxide ions ( $OH^-$ ) are in equal amounts. Thus, the ionic balance of water is neutral, not acidic or alkaline. The pH scale measures the concentration of hydrogen ions as a function of  $-\log[H^+]$ . The neutral concentration of hydrogen at  $1.00 \times 10^{-7}$  mole/liter defines water as a neutral solution having a pH of 7.0. Any deviation of pH is a function of minerals, or other constituents that are ionized in water, and therefore the resulting solution is not plain water. This condition is further evidenced in the fact that pure water is an electrical insulator, having no medium to transfer charge and current. Thus, the inherency of plain water being acidic or alkaline has not been established.

Furthermore, the Nakata et al. reference relies on the partition member 3 or 34 which is made from a hydrogen ion-conducting polymer electrolyte. (See Nakata at col. 7, lines 63-67 and col. 9, lines 45-47). Water is used to hydrate the electrolytic membrane which forms the electrolytic reaction site. This is not an electrolyte solution that is in contact with the anode or cathode. Rather, the instant invention, a page 13, lines 6-8, describes the "flow of electrolyte so that gas bubbles can be efficiently flushed out."

Thus, based on at least the foregoing reasons, the Nakata et al. reference fails to anticipate the photoelectrochemical cell of claim 37. For at least this reason, claim 38, which depends from claim 37, is likewise patentable. Therefore, Applicants respectfully request withdrawal of this rejection.

V. Response to the Rejection under 35 U.S.C. §103(a) of Claims 6-19 and 22-36 as being obvious over the Owada et al. reference and in view of the Delahoy reference (US 4,849,029).

Claim 6 recites an embodiment where individual subcells, while having insufficient voltage for water electrolysis when connected by the fourth scribe line to form unit cells, such unit cells do have sufficient voltage for electrolysis. An appropriate insulating layer covers predetermined areas of the back contact so that surfaces not resistant to corrosion are protected. The conducting layer, which is electrically connected to front electrode (Electrode A) via the segment between the third and fourth scribe lines, is deposited at predetermined areas on top of the insulating layer.

As admitted by the Examiner, the Owada et al reference fails to teach individual subcells that do not generate enough voltage for water electrolysis. As fully set forth above, the Owada et al. reference also fails to teach an oxygen evolution reaction layer and a hydrogen evolution reaction layer. The secondary Delahoy reference fails to overcome the deficiencies of the Owada et al. reference. Thus, the combination of the Owada et al. and Delahoy references do not teach or suggest the photoelectrode of claim 6.

The Owada et al. reference is non-analogous art to the claimed invention. Therefore, the disclosure of the Owada et al. reference should not be considered at all when evaluating the patentability of the claimed invention.

For a reference to be applicable in establishing a prima facie case of obviousness, the reference must either be (1) in the field of the applicant's endeavor, or (2) reasonably pertinent to the particular problem with which the inventor was concerned. With respect to the latter test, a reference is reasonably pertinent if, even though it may be in a different field from that of the inventor's endeavor, it is one which, because of the matter with which it deals, logically would have commended itself to an inventor's attention in considering his problem.

With respect to the first leg of this test for analogous art, the field of the Owada et al. reference (namely, a battery charging device utilizing a solar cell for charging when light is present and a capacitor for charging when light is not present) is quite different from the field of the claimed invention (namely, a photoelectrode, coupled to a series connected photovoltaic cell, used to generate hydrogen and oxygen from solar radiation). Thus, the field of the Owada et al. reference is clearly not within the field of the claimed invention.

With respect to the second leg of this test for analogous art, the problems addressed by the Owada et al. reference (namely, the difficulties associated with charging a battery using a solar cell without light) are quite different from the problems addressed by the claimed invention (namely, providing a photoelectrode capable of generating hydrogen and oxygen where the photovoltaic subcells powering the device do not produce sufficient voltage to generate hydrogen and oxygen). Thus, the Owada et al. reference is clearly non-analogous art to the claimed invention and, therefore, should not be considered at all when evaluating the patentability of the claimed invention.

However, even if the Owada et al. reference is properly considered, the teachings of the Delahoy reference cannot be properly combined with the teachings of the Owada et al. reference, as proposed by the Examiner. To establish a *prima facie* case of obviousness, three basic criteria must be met. First there must be motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. In this instance none of the three criteria have been met.

With regard to the first and second criteria, the Owada et al. reference teaches forming a solar cell having either series or parallel connections. The Delahoy reference, however, specifically teaches that the series connections of the cells are disadvantageous for electrolysis and that parallel connection via a common external buss bar is desired. (See Delahoy at col. 5, lines 20-25 and col. 6, lines 1-7). Contrary to the Examiner's reading of Delahoy, the panel disclosed in Fig. 1 and col. 5, lines 20-25 is not suitable for water electrolysis because it produces *too high* of a voltage. (See Delahoy at col. 6, lines 40-57, including tabulated data). The Delahoy reference teaches fabricating panels having parallel connections of cells with *low voltage* in order to raise the current output. (See Delahoy at col. 6, lines 1-7 and lines 54-57).

Finally, with regard to the third criteria, the Delahoy reference does not disclose a fourth scribing applied to certain subcells to create sufficient voltage to drive water electrolysis. Rather, the Delahoy reference teaches that "in the fabrication of typical photovoltaic panels, it [is] (sic.) necessary to make three successive sets of scribing for three successive layers. (See Delahoy at col. 1, lines 45-47). However, the Delahoy reference

teaches, as one of its objectives, to reduce the number of scribings. (See Delahoy at col. 2, lines 12-14). Thus, the Delahoy reference teaches away from the invention of claim 6 and from any combination with the Owada et al. reference. Therefore, neither reference suggests using solar cells, especially those having an insufficient voltage, for water electrolysis under illumination as recited in claim 6.

Thus, the combination of the Owada et al. and Delahoy references fails to teach or suggest every claim limitation. Thus, Applicants respectfully request withdrawal of these rejections.

#### VI. Newly added Claims 39 and 40 Recite Further Patentably Distinct Embodiments

Applicants have added Claims 39 and 40 which further describe certain additional embodiments of the present invention. Support for these claims is found in the specification and drawings. Applicants submit that such new claims are properly presented and that no additional searching is required.

For example, new dependent claims 39 and 40 describe the photoelectrochemical cells shown in Figs. 1-3. Therefore, the Examiner is respectfully requested to also allow these new claims.

#### VII. Conclusion

Based on the foregoing remarks, Applicants have distinguished the invention recited in Claims 1-40 over the cited art of record. Therefore, Applicants believe that the claims are patentable and in condition for allowance. Thus, Applicants respectfully request withdrawal of the rejections and issuance of a Notice of Allowance.